Effluent Quality-Based Drainfields

Recommended Standards and Guidance for
Performance, Application, Design and Operation & Maintenance

Washington State Department of
Health

Washington State Department of Health
Office of Environmental Health & Safety
Wastewater Management Program
New Market Industrial Center
7171 Cleanwater Lane, Building 4
PO Box 47825
Olympia, Washington 98504-7825

Tel: 360.236.3062
FAX: 360.236.2257
Webpage: http://www.doh.wa.gov

This page is intentionally blank.

Preface

The recommended standards contained in this document have been developed for statewide application. Regional differences may, however, result in application of this technology in a manner different than it is presented here. In some localities, greater allowances than those described here may reasonably be granted. In other localities, allowances that are provided for in this document may be restricted. In either setting, the local health officer has full authority in the application of this technology, consistent with Chapter 246-272 WAC and local jurisdictional rules. If any provision of these recommended standards is inconsistent with local jurisdictional rules, regulations, ordinances, policies, procedures, or practices, the local standards take precedence. Application of the recommended standards presented here is at the full discretion of the local health officer.

Local jurisdictional application of these recommended standards may be:

1) **Adopted as part of local rules, regulations or ordinances—**When the recommended standards, either as they are written or modified to more accurately reflect local conditions, are adopted as part of the local rules, their application is governed by local rule authority.

2) **Referred to as technical guidance in the application of the technology—**The recommended standards, either as they are written or modified to more accurately reflect local conditions, may be used locally as technical guidance.

Application of these recommended standards may occur in a manner that combines these two approaches. How these recommended standards are applied at the local jurisdictional level remains at the discretion of the local health officer and the local board of health.

The recommended standards presented here are provided in typical rule language to assist those local jurisdictions where adoption in local rules is the preferred option. Other information and guidance is presented in text boxes with a modified font style to easily distinguish it from the recommended standards.

Acknowledgements—

The Department of Health Wastewater Management Program appreciates the contribution of many persons in the on-going development, review, and up-dating of the Recommended Standards and Guidance documents. The quality of this effort is much improved by the dedication, energy, and input from these persons, including:

- Geoflow, Inc.
- Lombardi and Associates
- Orenco Systems, Inc.
- Puget Sound Water Quality Action Team
- Sun-Mar Corporation
- Washington State On-Site Sewage Association (WOSSA)
- Washington State On-Site Sewage Treatment Technical Review Committee (TRC)
- Waste Water Technologies

Table of Contents

Introduction—

In a conventional on-site sewage system, consisting of a septic tank and a sub-surface soil absorption system—or drainfield—the soil environment provides the wastewater treatment. The on-site sewage system rules (Chapter 246-272 WAC) assure a suitable soil environment to treat septic tank effluent by establishing requirements for vertical separation and soil type-based application rates, in addition to other system design, installation, and operational elements.

For example, a site with Soil Type 3 soils (fine sands, loamy coarse sands, loamy medium sands) requires, for a conventional gravity flow septic tank and drainfield system, three feet of vertical separation, with an application rate of 0.8 gallons per day / square foot. Under these conditions the drainfield serves multiple functions: (1) distribute the effluent to the soil; (2) treat the effluent in the soil environment around the drainfield; and, (3) dispose of the treated wastewater through groundwater recharge. But what about sites where the soils are either too coarse or too shallow to provide adequate treatment?

For sites where the soil environment is inadequate for wastewater treatment, the "balance" of public health protection may be maintained by offsetting decreasing wastewater treatment capability in the soil with either improved means of distributing septic tank effluent to the soil (via pressure) or increasing pre-treatment levels. As pre-treatment levels increase, reliance on the soil environment for wastewater treatment decreases. The drainfield retains its function to distribute effluent to the soil for final treatment and disposal.

This document presents information about this link between effluent quality—pre-treatment levels—and drainfield design.

1. Performance Standards—

1.1. Pre-Treatment Performance—For the purpose of this document, there are five recognized categories of wastewater, based on the level or degree of pre-treatment. These are:

1.1.1. Treatment Standard 1— A thirty-day average of less than 10 milligrams per liter of biochemical oxygen demand (5-day, BOD_5), 10 milligrams per liter total suspended solids (TSS), and a thirty-day geometric mean of less than 200 fecal coliform per 100 milliliters.

1.1.2. Treatment Standard 2— A thirty-day average of less than 10 milligrams per liter of biochemical oxygen demand (5-day, BOD_5), 10 milligrams per liter total suspended solids (TSS), and a thirty-day geometric mean of less than 800 fecal coliform per 100 milliliters.

1.1.3. NSF Standard No. 40 , Class I—

(a) $CBOD_5$

- ♦ 7-day average 40 mg/l
- ♦ 30-day average 25 mg/l

(b) TSS

- ♦ 7-day average 45 mg/l
- ♦ 30-day average 30 mg/l

1.1.4. NSF Standard No. 40 , Class II—

(a) $CBOD_5$

- Not more than 10% of the samples > 60 mg/l

(b) TSS

- Not more than 10 % of samples > 100 mg/l

1.1.5. Residential Septic Tank Effluent—

(a) BOD_5

- 100 – 300 mg/l

(b) TSS

- 100 – 350 mg/l

1.2. On-Site Sewage System Performance—

1.2.1. The overall on-site wastewater treatment and disposal system, incorporating one of the five levels of pre-treatment provided in Section 1.1, above, and an appropriate final treatment and disposal component, are expected to provide wastewater treatment comparable with Treatment Standard 2.

2. Application Standards—

2.1. Permitting—

2.1.1. An installation permit and, if required, an operational permit must be obtained from the local health jurisdiction before installation of an on-site sewage system.

2.1.2. For sites where either Treatment Standard 1 or 2 must be met, some means acceptable to the local health jurisdiction must be implemented to assure proper on-going operation and maintenance (O&M) of the on-site sewage system components as long as the facility is served by the on-site sewage system. The following options may be used separately or in combination. Approaches to assuring long-term O&M of on-site sewage systems include:

(a) recording the requirement for an on-going service contract on the property deed;

(b) issuing an operating permit (in addition to the initial installation permit), with the requirement for maintaining a service contract; and,

(c) requiring a management entity to provide O&M assurance. Examples of management entities include: cities & towns, public utility districts, water & sewer districts, special-use districts, and corporations and home-owner associations with demonstrated capacity to assure long-term management.

2.1.3. Local health jurisdictions may implement O&M assurance measures (see subsection 2.2.2) for sites other than those where Treatment Standard 1 or 2 is required to be met.

2.2. Addressing Specific Conflicts Between Chapter 246-272 WAC and Recommended Standards and Guidance—Table IV. in WAC 246-272-11501 Design, establishes effluent distribution methods for various Soil Types and soil depths in terms of vertical separation (see Appendix A). The provisions of Table IV, including the footnotes, present the on-site sewage system designer and local health jurisdiction with two items of potential conflict between the rules and the application of alternative pre-treatment systems. These items are: (1) the requirement for pressure distribution when pre-treatment to Treatment Standard 2 is provided; and, (2) the limitation of mound pre-treatment to an intermittent sand filter on sites where the soil depth is between 12 and 18 inches. The local health officer may address these issues by:

2.2.1. Exercising discretion by meeting the intent of the on-site sewage system rules (see guidance, below); or,

2.2.2. Waive either footnoted or pressure distribution provisions through the waiver process of WAC 246-272-25001.

Conflicts Between Chapter 246-272 WAC and Recommended Standards and Guidance—

There are two items of potential conflict to be considered:

1) *For those Soil Type and vertical separation combinations where footnote 1 is noted, pre-treatment equal to Treatment Standard 2 (TS2) is required, in addition to pressure distribution (PD). What about a pre-treatment system that discharges via gravity? Can gravity flow distribution be used in the drainfield or other final treatment / disposal component provided that pre-treatment is at least equal to Treatment Standard 2?*

To assist with response to these questions, a review of the intent of footnote 1 may be useful. Pre-treatment equal to Treatment Standard 2 and Pressure Distribution was linked to provide a high level of public health protection in those settings (limited vertical separation between 12 and 24 inches). If, the health officer concludes that the proposed on-site sewage system—with pre-treatment at least equal to Treatment Standard 2 and any other design or management elements—will provide at least the same level of public health protection as that provided by TS2 and PD, then gravity flow distribution in the drainfield or other final treatment /disposal component would be consistent with the intent of the rules.

2) *For those Soil Type and vertical separation combinations where footnote 2 is noted, pre-treatment for a mound system (equal to Treatment Standard 2) is limited to an intermittent sand filter. What about a pre-treatment system other than an intermittent sand filter? Can a treatment unit other than an intermittent sand filter meeting Treatment Standard 2 be used as the pre-treatment method preceding a mound?*

To assist with response to these questions, a review of the intent of footnote 2 may be useful. At the time the on-site rules were under revision (1989-1994, effective date 1/1/95) mound systems were the only alternative on-site sewage system that could be used on sites with as little as 12 inches of soil depth. <u>The Guidelines for the Use of Mound Systems</u> conditioned the placement of mounds on sites with 12 – 18 inches of soil to pre-treatment by an intermittent sand filter. In the same manner that linking Treatment Standard 2 pre-treatment with pressure distribution (item 1, above) provided an extra measure of public health protection, pre-treatment by an intermittent sand filter was linked to use of a mound on shallow soils. Consistent with the mound guidelines, this provision was placed in the rules for sites where the soil depth was between 12 and 18 inches.

<u>The Recommended Standards and Guidance for Mound Systems (April 5, 1999</u>) have expanded the pre-treatment provision.

> *"A minimum of 12 inches of undisturbed, unsaturated, original soil is required when the mound is preceded by an intermittent sand filter <u>or other pre-treatment unit identified on the List of Approved Systems and Products as meeting all three parameters of Treatment Standard 2.</u>*

Since the footnote-imposed requirement for mound pre-treatment by an intermittent sand filter was consistent with the mound guidelines when the rules were written, maintaining consistency with the current mound guidance would also be consistent with the intent of the rules. From this perspective, an ATU listed as meeting all three parameters of Treatment Standard 2 could be used in lieu of an intermittent sand filter for pre-treatment with a mound on 12 to 18 inches of soil depth.

In addition to the approaches mentioned above, the local health officer may waive either the footnoted or pressure distribution provisions. The process for waiver of state regulations is detailed in WAC 246-272-25001.

2.3. Disinfection—When disinfection is used to meet the fecal coliform parameter of Treatment Standard 1 or 2, refer to the INTERIM—Recommended Standards and Guidance for Disinfection Methods and Equipment, DOH (September 1999).

2.4. Disposal Component—

2.4.1. Direct discharge of effluent to surface water or upon the ground surface is prohibited by WAC 246-272-11501(2)(a). Subsurface disposal is required.

2.4.2. Drainfield design allowances vary according to pre-treatment performance levels. See Table I.

(a) For alternative systems with performance results meeting all three parameters of Treatment Standard 1 & 2 (BOD_5, TSS & fecal coliform), refer to Column A.

The List of Approved Systems and Products, a publication of the Department of Health, identifies which wastewater treatment systems and products meet all three, or only two, of the parameters of Treatment Standards 1 and 2.

(b) For alternative systems with performance results meeting two of the three parameters of Treatment Standard 1 & 2, (BOD_5 & TSS, but not fecal coliform) where add-on disinfection is provided in accordance with subsection 2.3, refer to Column B.

(c) For alternative systems with performance results meeting two of the three parameters of Treatment Standard 1 & 2, (BOD_5 & TSS, but not fecal coliform) where add-on disinfection is NOT provided, refer to Column C.

(d) For alternative systems tested to and meeting NSF Standard No. 40 Class I, where add-on disinfection is NOT provided, refer to Column D.

(e) For residential septic tank effluent, refer to Column E

2.4.3. Where provided in Table I, drainfields may be reduced in size as much as 50% smaller than that required for conventional gravel-filled drainfields receiving residential septic tank effluent only if all of the following conditions are met:

(a) the wastewater being treated and disposed is from a residence or has the wastewater strength and flow volume typical of a residence;

(b) the soil does not contain appreciable amounts of expanding clay (see Appendix B);

(c) drainfield size (installed) is based upon the size required for conventional gravity, gravel-filled drainfields receiving residential septic tank effluent according to WAC 246-272-11501;

- ♦ For mound systems, the mound size (installed) is based upon the Recommended Standards and Guidance for Mounds;

(d) the initial and replacement drainfield <u>area</u> must be equal to that required for a conventional gravity, gravel-filled drainfield receiving residential septic tank effluent according to WAC 246-272-11501;

- ♦ For mound systems, the <u>area</u> required must be equal to that required for a full-sized mound system, according to the Recommended Standards and Guidance for Mounds; and,

(e) an observation port must be installed in a representative location on each drainfield line. Some drainfield lines may require additional observation ports to achieve observations representative of the entire drainfield line.

2.4.4. The size and design of the disposal component must be consistent with the methods and procedures indicated by WAC 246-272-09001, WAC 246-272-11001 and WAC 246-272-11501.

2.4.5. Disposal component location must meet minimum horizontal setback distances as specified by WAC 246-272-09501, and 246-272-16501.

2.4.6. Development using alternative systems must meet the minimum land area requirements specified in WAC 246-272-20501.

The general technical concept supporting reducing the size of disposal components is based on the relationship between treated wastewater quality and the development of soil infiltration-impeding bio-mat at the disposal component interface with the receiving soil. The reduction of drainfield size was first generally accepted with the application of intermittent sand filter technologies. Drainfield size reduction for final treatment and disposal or dispersal of intermittent sand filter effluent is well supported in the scientific and academic literature. Extending the allowance of installing smaller drainfields (when compared to septic tank effluent-receiving disposal components) to other alternative systems, while generally accepted, is not yet as well supported in the scientific and academic literature, but neither is it unsupported.

The upside of allowing drainfield size reduction is that a lower initial system cost can be achieved. The downside is that whenever, for whatever reasons, the reduced-size drainfield fails, the system owner is faced with an often extensive and expensive repair. All other design and system use elements being equal, reducing drainfield size will likely impact drainfield longevity. Opting to reduce a drainfield size, and the amount to reduce it by, needs to be site-specific, thoughtful design decision. The client needs to be fully aware of the benefit and the risk involved. In this context, failure to establish, reserve and protect for future use adequate expansion and replacement area for a reduced-size drainfield following a treatment unit is a poor design and operation & maintenance decision, and is inconsistent with these recommended standards.

Some sites (existing lots of record or repair sites) may prohibit the establishment of 100% of the initial and replacement area. Local health jurisdictions are encouraged, when issuing permits for such sites, to address (mitigate) the potential for drainfield problems by assuring that the necessary operation and maintenance needed to provide the expected high-quality effluent is provided for the life of the system. While these recommended standards allow up to a 50% drainfield size reduction, the application of this allowance should be evaluated on a site-by-site basis, as a full 50% reduction may not be a prudent design decision on every site throughout Washington state. As the success of long-term use of a reduced-size drainfield depends on maintaining a high-quality effluent, the local health jurisdiction is strongly encouraged to establish requirements to help assure that long-term O&M is provided for the treatment unit and the remaining sewage system components.

Table I.
Drainfield Sizing Allowances and Distribution Methods, by Pre-Treatment Levels and Vertical Separation

	Column A			***Column B***			***Column C***			***Column D***			***Column E***		
Pre-Treatment Levels➔➔	TS1 & 2 (Tested to BOD_5, TSS, & fecal coliform)			TS1 & 2 (Tested to BOD_5 & TSS only) Add-on disinfection for fecal coliform reduction (see Note 1)			$\leq$10 mg/l BOD_5, $\leq$ 10 mg/l TSS (Tested to BOD_5 & TSS only) No disinfection used			NSF Class I (Tested to BOD_5 & TSS only) No disinfection used			Residential Septic Tank Effluent		
Vertical Separation➔➔➔	≥12", <24"	≥24", <36"	≥36"	≥12", <24"	≥24", <36"	≥36"	≥12", <24"	≥24", <36"	≥36"	≥12", <24"	≥24", <36"	≥36"	≥12", <24"	≥24", <36"	≥36"
Minimum Available Area *(see Note 2)*	100%	100%	100%	100%	100%	100%	NA	100%	100%	NA	100%	100%	NA	100%	100%
Minimum Installed Size *(see Note 2)*	50%	50%	50%	100%	50%	50%	NA	50%	50%	NA	100% *(see Note 3)*	100% *(see Note 3)*	NA	100%	100%
Vertical Separation➔➔➔	≥12", <24"	≥24", <36"	≥36"	≥12", <24"	≥24", <36"	≥36"	≥12", <24"	≥24", <36"	≥36"	≥12", <24"	≥24", <36"	≥36"	≥12", <24"	≥24", <36"	≥36"
Gravity Distribution	No / Yes (see Note 4)	No / Yes (see Note 4)	Yes	No / Yes (see Note 4)	No / Yes (see Note 4)	Yes	NA	No	Yes, Except 1A & 2A soils (see Note 5 & 6)	NA	No	Yes, Except 1A & 2A soils (see Note 5 & 6)	NA	No	Yes, Except 1A & 2A soils (see Note 5 & 6)
Pressure Distribution	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes (see Note 5)	Yes	NA	Yes (see Note 5)	Yes (see Note 5)	NA	Yes (see Note 5)	Yes (see Note 5)

Notes:

NA = Not Available — Regardless of soil type, sites with ≥12" to <24" vertical separation must meet pre-treatment levels of TS2 (See Columns A or B)

1) See INTERIM Recommended Standards & Guidance for Disinfection Methods and Equipment, DOH (December 1999).

2) 100% & 50% relates to the area and drainfield size required for conventional gravity gravel-filled drainfields receiving residential septic tank effluent, Chapter 246-272 WAC. These area requirements are for the initial drainfield (SSAS) area and the replacement drainfield (SSAS) area.

3) UR = Under Review The Department of Health and the Technical Review Committee are researching & considering the merit of drainfield reduction.

4) Inconsistency between WAC 246-272-11501, TABLE IV, and the Recommended Standards & Guidance documents for various alternative systems. See subsection 2.2. of this document for approaches to resolving these inconsistencies.

5) May be installed in Soil Type 1A only with pressure distribution and a sand-lined drainfield trench sand filter with a minimum of 24 inches of treatment media is used as the effluent disposal component

6) May be installed in Soil Type 2A only with pressure distribution.

What is the difference between Column A & Column B?

The differences between Column A and Column B relate to the level of product or system performance, based upon the degree or range of product testing. Column A is distinguished from Column B only in that the systems and products that fall in this category have been identified as meeting all three of the performance parameters of Treatment Standards 1 and 2. While systems and products in Column B perform similarly to those in Column A, the level of public health protection is less due to the untested nature of add-on disinfection needed to meet the fecal coliform component of the treatment standards.

Product testing to a recognized standard helps assure the capacity for on-going product performance when placed in use with an on-site sewage system. For aerobic treatment units (ATUs) we currently rely on product performance testing according to the ANSI/NSF Standard 40. In the context of applying ATU technology to many sites, particularly limited sites, in Washington the NSF testing protocol falls short in that it tests / reports product performance in only two parameters, $CBOD_5$ and TSS. Fecal coliform reduction performance level is not customarily identified, though some manufacturers have requested /arranged for such evaluation as part of their products testing regime.

The lack of test-based information on the fecal coliform reduction performance of most ATUs available and the absence of similar testing regimes for add-on disinfection equipment, leads to a lower level of assurance of overall system performance when striving to meet either Treatment Standard 1 or 2. This situation also impacts the application of intermittent sand filters to Treatment Standard 1 sites or recirculating gravel filters to either Treatment Standard 1 or Treatment Standard 2 sites, where add-on disinfection is required to meet the fecal coliform parameters of the performance standards.

The wastewater treatment scheme presented in Table I relates to this level of performance assurance. Treatment units with demonstrated / tested performance for all three parameters of Treatment Standard 1 & 2 have a higher level of assurance than treatment units tested for only BOD_5 ($CBOD_5$) and TSS. Reliance on technical expertise of licensed professional engineers and on-site sewage system designers is the current method to help assure the proper matching of treatment unit with add-on disinfection to meet the fecal coliform parameter of Treatment Standards 1 or 2.

With the increasing demand for options on limited sites, disinfection equipment manufacturers are beginning to subject their equipment to testing protocols consistent with the rigors of ANSI/NSF Standard 40. It is hoped that in the near future disinfection equipment manufacturers will have product performance test results that will allow accurate matching of alternative pre-treatment units with specific effluent disinfection equipment. This is contrasted with the current status where proper selection of add-on disinfection must rely on engineering judgement alone.

In the future, if the trend toward product performance testing for fecal coliform continues, on-site sewage system designers will be able to match known fecal coliform reduction levels of various alternative pre-treatment units with the tested influent and effluent capacity of various disinfection equipment options. Knowing the fecal coliform reduction capacity of both pre-treatment unit and disinfection equipment will provide an alternative to subjecting specific ATU models with specific disinfection equipment to ANSI/NSF Standard 40 testing. By independently testing both—pre-treatment units and disinfection equipment to the same level of testing scrutiny, determining each model's fecal coliform reduction capacity and their specific wastewater application needs (such as turbidity range, pretreatment needs, etc.), a high level of performance assurance (equal to testing specific models & equipment or methods together) can be achieved. When this future level of performance assurance becomes reality, the need to address Column A & Column B systems differently will cease.

Why isn't there a difference between Column D and Column E? What is UR—Under Review—by the Department and the Technical Review Committee?

The Department of Health and the Technical Review Committee is currently reviewing scientific and academic literature about, and other state's experience with, drainfield sizing allowances (reductions) for treatment units meeting the NSF Class I performance levels. Previous versions of guidelines for ATUs have not provided for drainfield size reduction (nor any other design element provision) based upon product performance to the NSF Class I level.

3. Design— The design elements of drainfields and other final treatment / disposal components are addressed in rule (Chapter 246-272 WAC) or other guidance documents:

3.1. Conventional gravel-filled gravity-flow drainfields: see Chapter 246-272 WAC.

3.2. Conventional gravel-filled pressure-distribution drainfields: see Chapter 246-272 WAC and the Recommended Standards and Guidance for Pressure Distribution (DOH).

3.3. Gravelless gravity-flow drainfields: see Chapter 246-272 WAC and the Recommended Standards and Guidance for Gravelless Drainfields (DOH).

3.4. Gravelless pressure-distribution drainfields: see Chapter 246-272 WAC, the Recommended Standards and Guidance for Gravelless Drainfields (DOH), and the Recommended Standards and Guidance for Pressure Distribution (DOH).

3.5. Mounds: see Chapter 246-272 WAC, the Recommended Standards and Guidance for Mounds (DOH) and the Recommended Standards and Guidance for Pressure Distribution (DOH)

3.6. At-Grade Drainfield Systems (Under Development by DOH & the TRC 9/99): See Chapter 246-272 WAC and the Recommended Standards and Guidance for At-Grade Drainfield Systems (DOH) and the Recommended Standards and Guidance for Pressure Distribution (DOH)

4. Operation & Maintenance—Each of the various types of drainfields and other final treatment / disposal components addressed in Section 3 have general and type-specific requirements for Operation & Maintenance to assure satisfactory on-going performance. Refer to the documents mentioned in Section 3 for matters relating to Operation & Maintenance.

Appendix A

TABLE IV in WAC 246-272
Methods of Effluent Distribution for Soil Types and Depths

	Vertical Separation			
Soil Type	**< 1 foot**	**≥ 1 foot to < 2 feet**	**≥ 2 feet to < 3 feet**	**≥ 3 feet**
1A	Not allowed	Pressure Distribution (see note)[1 & 2]	Pressure Distribution (see note)[1]	Pressure Distribution (see note)[1]
2A	Not allowed	Pressure Distribution (see note)[1 & 2]	Pressure Distribution	Pressure Distribution
1B - 6	Not allowed	Pressure Distribution (see note)[1 & 2]	Pressure Distribution	Gravity Distribution

[1] System meeting Treatment Standard 2 required.
[2] Mound systems installed where the original, undisturbed, unsaturated soil depth is between 12 and 18 inches, require pretreatment by an intermittent sand filter.

Appendix B

The following information provided by Lisa Palazzi is being re-written for greater clarity and understanding by a broader audience.

Please Note: *The following information has been provided by Lisa Palazzi to address the issue of* appreciable amounts of expandable clay*. Ms. Palazzi is a private-sector soil scientist and a member of the department's Technical Review Committee.*

A Vertisol is one of the 11 Taxonomic Soil Orders, and is defined as having *slickensides* *(smeared planes within the soil profile) at least 10 inches thick within the top 40 inches of soil, and having 30% clay content and having cracks that open and close periodically. The slickensides and cracks imply that the clay content is primarily expanding clays, as those features occur concurrently only with expanding clays. Vertisols are identified in general textbooks as being generally incapable of supporting septic drainfields, although many septic systems are installed and functioning in Texas Vertisols. This success however, is thought to be a result of their very low rainfall climate.*

Expanding clays - such as montmorillonite or smectite or bentonite - can be defined on a mineralogic level as being composed of a 2:1 alumino-silicate crystalline lattice, as compared to non-expanding clays - such as kaolinite (the red Georgia clays) - which have a 1:1 crystal lattice form. From a more practical perspective, they can be defined by a measurement of how much they shrink when taken from a saturated water content to a dry water content. That measurement is called a Coefficient of Linear Extensibility (COLE) and a 9% change is considered definitive of having a significant montmorillonite content. At another scale, the distance between two montmorillonite crystal lattices when dry is reported as being 9.6 angstroms; and when exposed to 50% relative humidity, expanding to 10's or even hundreds of angstroms. So it is obvious that even a very small amount of expanding clay can have a huge effect on soil drainage characteristics. 5-10% content could be considered "appreciable".

It is important to note that there are few areas with expanding clays north of the terminus of the continental glacier (about Tenino for western Washington). Areas south of that however could have some Vertisols, although they are not terribly common. If we need a measure of expansion potential, the COLE process could be applied with fairly simple tools. One simply mixes a soil/water solution to the point where the clay soil is almost saturated, but can still be formed into a "worm" or rod-shaped lump. The length of the rod is measured. Then the rod is placed in an oven to dry (250 degrees for about an hour should be enough), then re-measured. If the length of the rod decreases by more than 3-5%, there is probably enough expanding clay to affect soil drainage potential. I chose 3-5% somewhat arbitrarily mainly because it is about one third to one half that of that used to indicate significant content of montmorillonite (9%).

Appendix C

GLOSSARY OF TERMS—

Term	*Meaning / Description*
Alternative System	An on-site sewage system other than a conventional gravity system or conventional pressure distribution system. Properly and maintained alternative systems provide equivalent or enhanced treatment performance as compared to conventional gravity systems.
Approved List	"List of Approved Systems and Products", developed annually and maintained by the department and containing the following: (a) List of proprietary devices approved by the department; (b) List of specific systems meeting Treatment Standard 1 and Treatment Standard 2; (c) List of experimental systems approved by the department; (d) List of septic tanks, pump chambers, and holding tanks approved by the department.
Biochemical Oxygen Demand (BOD_5)	A test which measures the molecular oxygen used by microorganisms during a five day incubation period at a temperature of 20^0C (68^0F) for the biochemical degradation of organic material (CARBONACEOUS DEMAND), and the oxygen used by microorganisms to oxidize inorganic material such as sulfides and ferrous iron. It also may measure the amount of oxygen used to oxidize reduced forms of nitrogen such as ammonia and organic nitrogen (NITROGENOUS DEMAND) if the microorganisms capable of mediating the reaction are present in the sample. .
Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)	Same as the 5-day biochemical oxygen demand (BOD_5) test, except that the NITROGENOUS DEMAND is <u>prevented</u> by addition of an inhibitory chemical to the sample.
Coliform (Bacteria)	A group of bacteria that produce gas and ferment lactose, some of which are found in the intestinal tract of warm-blooded animals. They are indicators of potential ground water and/or surface water contamination with such fecal material. The coliform group of organisms includes all of the aerobic and facultative anaerobic, gram-negative, non-spore-forming, rod-shaped bacteria that ferment lactose with gas formation within 48 hours at 35^O C.
Conventional Gravity System	An on-site sewage system consisting of a septic tank and a subsurface soil absorption system with gravity flow distribution of the effluent.
Conventional Pressure Distribution System	An on-site sewage system consisting of a septic tank and a subsurface soil absorption system with pressure distribution of the effluent.
Designer	See Licensed On-site Sewage System Designer
Disposal Component	A subsurface absorption system (SSAS) or other soil absorption system receiving septic tank or other pretreatment device and transmitting it into original, undisturbed soil.
Drain Rock	Clean, washed gravel, varying in size from ¾inch to 2 ½inches.
Drainfield (Conventional)	An area in which perforated piping is laid in drain rock-packed trenches, or excavations (seepage beds) for the purpose of distributing the effluent from a wastewater treatment unit into original, undisturbed soil.
Effluent	Liquid which is discharged from an on-site sewage system component, such as a septic tank (septic tank effluent) or sand filter (sand filter effluent).
Engineer	See Licensed Professional Engineer
Failure	A condition of an on-site sewage system that threatens the public health by inadequately treating sewage or creating a potential for direct or indirect contact between sewage and the public. Examples of failure include: (a) sewage on the surface of the ground; (b) sewage backing up into a structure caused by slow absorption of septic tank effluent; (c) sewage leaking from a septic tank, pump chamber, holding tank, or collection system; (d) cesspool or seepage pits where evidence of ground water or surface water quality degradation exists; or (e) inadequately treated effluent contaminating ground water or surface water. (f) noncompliance with standards stipulated on the permit.
Fats, Oils & Greases (Fog)	FOG is a measure of the amount of fatty matter from animal and vegetable sources and hydrocarbons from petroleum products and waxes, such as from lotions, shampoos, and tanning oils. High levels of fats, oils and greases in the wastewater stream may interfere with wastewater treatment efficiency.

Term	***Meaning / Description***
Fecal Coliform (Bacteria)	Coliform bacteria specifically originating from the intestines of warm-blooded animals, used as a potential indicator of ground water and/or surface water pollution.
Final Treatment/Disposal Unit	That portion of an on-site sewage system designed to provide final treatment and disposal of the effluent from a wastewater treatment unit, including, but not limited to, absorption fields (drainfields), sand mounds and sand-lined trenches.
Influent	Wastewater, partially or completely treated, or in its natural state (raw wastewater), flowing into a reservoir, tank, treatment unit, or disposal unit.
Licensed On-Site Sewage System Designer	A person licensed by the Washington State Department of Licensing to match site and soil characteristics with appropriate on-site sewage technology.
Licensed Professional Engineer	A person licensed by the Washington State Department of Licensing as a professional engineer consistent with Chapter 18.43, RCW.
On-Site Sewage System	An integrated arrangement of components for a residence, building, industrial establishment or other places not connected to a public sewer system which: (a) Convey, store, treat, and/or provide subsurface soil treatment and disposal on the property where it originates, upon adjacent or nearby property; and (b) Includes piping, treatment devices, other accessories, and soil underlying the disposal component of the initial and reserve areas.
Pressure Distribution	A system of small diameter pipes that apply effluent fairly uniformly over the entire absorption area, as described in the "Recommended Standards and Guidance for Pressure Distribution Systems" by the Washington State Department of Health. (See Conventional Pressure Distribution System.)
Proprietary Device Or Method	A device or method classified as an alternative system, or a component thereof, held under a patent, trademark or copyright.
Raw Wastewater	Wastewater before it receives any treatment.
Residential Sewage	Sewage having the consistency and strength typical of wastewater from domestic households.
Routine Servicing	Servicing all system components as needed, including product manufacturer's requirements / recommendations for service.
Septic Tank	A water tight pretreatment receptacle receiving the discharge of sewage from a building sewer or sewers, designed and constructed to permit separation of settleable and floating solids from the liquid, detention and anaerobic/facultative digestion of the organic matter, prior to discharge of the liquid.
Service Interval	The time period between planned site visits to perform various system monitoring functions such as checking equipment, renewing depleted disinfectant chemical supply, and collecting samples. The service intervals may be specified by contracts, operation plans, or local health jurisdiction permits.
Sewage	Any urine, feces, and the water carrying human wastes including kitchen, bath, and laundry wastes from residences, building, industrial establishments or other places. For the purposes of this document, "sewage" is generally synonymous with domestic wastewater. Also see "residential sewage."
Subsurface Soil Absorption System - "SSAS"	A system of trenches three feet or less in width, or beds between three feet and ten feet in width, containing distribution pipe within a layer of clean gravel designed and installed in original, undisturbed soil for the purpose of receiving effluent and transmitting it into the soil.
Suitable Soil	Original, undisturbed soil of types 1B through 6.
Total Suspended Solids (TSS)	Suspended solids refer to the dispersed particulate matter in a wastewater sample that may be retained by a filter medium. Suspended solids may include both settleable and unsettleable solids of both inorganic and organic origin. This parameter is widely used to monitor the performance of the various stages of wastewater treatment, often used in conjunction with BOD_5 to describe wastewater strength. The test consists of filtering a known volume of sample through a weighed filter membrane that is then dried and re-weighed.
Treatment Component	A class of on-site sewage system components that modify and/or treat sewage or effluent prior to the effluent being transmitted to another treatment component or a disposal component. Treatment occurs by a variety of physical, chemical, and/or biological means. Constituents of sewage or effluent may be removed or reduced in concentrations.
Treatment Standard 1	A thirty-day average of less than 10 milligrams per liter of biochemical oxygen demand (5-day, BOD_5), 10 milligrams per liter total suspended solids (TSS), and a thirty-day geometric mean of less than 200 fecal coliform per 100 milliliters.
Treatment Standard 2	A thirty-day average of less than 10 milligrams per liter of biochemical oxygen demand (5-day, BOD_5), 10 milligrams per liter total suspended solids (TSS), and a thirty-day geometric mean of less than 800 fecal coliform per 100 milliliters.